

Reference Design:

HFRD-32.0

Rev. 2; 11/08

REFERENCE DESIGN

Quad-SFP Host Adapter

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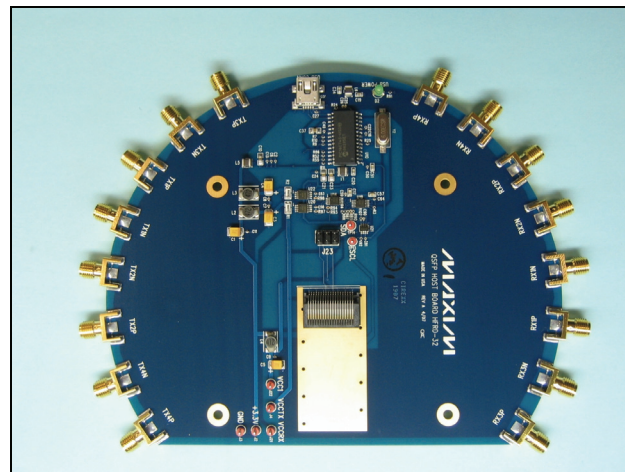
1 Overview

High Frequency Reference Design 32.0 (HFRD-32.0) is a host adapter board that supports Quad-SFP (QSFP) modules. HFRD-32.0 routes power and I²C serial-communication support, and translates the high-speed, QSFP interconnect to SMA connectors.

HFRD-32.0 is suitable for evaluating QSFP modules operating from 1Gbps to 10Gbps. The material used in the construction of the board is inexpensive and lossy FR-4 with a loss tangent of approximately 0.02. The differential data lines are lightly coupled 6mil-wide microstrip lines. These lines are located on the back of the board to eliminate the stub effect of the through-hole vias needed to connect to the QSFP interface connector. Host-side monitoring of VCC_TX and VCC_RX supply currents and voltages provides additional confidence that the external supply is adequate and that the module is not drawing excessive current. The landing area for the QSFP module meets the mechanical requirements described in the QSFP specification version 1.0 and is, therefore, compatible with QSFP cages, latches, and housings. The software that supports the host adapter board relies on a Microsoft Windows®-based personal computer equipped with USB.

HFRD-32.0 reduces the risk associated with experimenting with QSFP modules by supplying the user-interface software and the necessary hardware interface to support QSFP module development.

Microsoft Windows is a registered mark of Microsoft Corporation.



1.1 Features

- Schematics
- Bill of Materials
- Gerber plot files available
- Single 3.3V supply
- USB
- Serial interface to QSFP
- Graphic user interface (GUI) software
- Assembled and tested

2 Obtaining Additional Information

Limited quantities of the Quad-SFP Host Adapter (HFRD-32.0) are available. For more information about this reference design or to obtain a board, please email your request to: <https://support.maxim-ic.com/>.

3 Typical Use

Figure 1 shows a typical testing configuration for a QSPF module. Two HFRD-32.0 boards are used in this example.

The test apparatus shows an Agilent ParBERT™ pattern generator which fills the channels and

introduces aggressor signals for crosstalk evaluation. The Agilent 70843B supplies the “victim” signal. The HFRD-32.0 host adapter board provides the interface between the lab equipment and the module. The Tektronix CSA8000 oscilloscope produces eye diagrams. Not shown is a personal computer needed to monitor and control the QSPF modules.

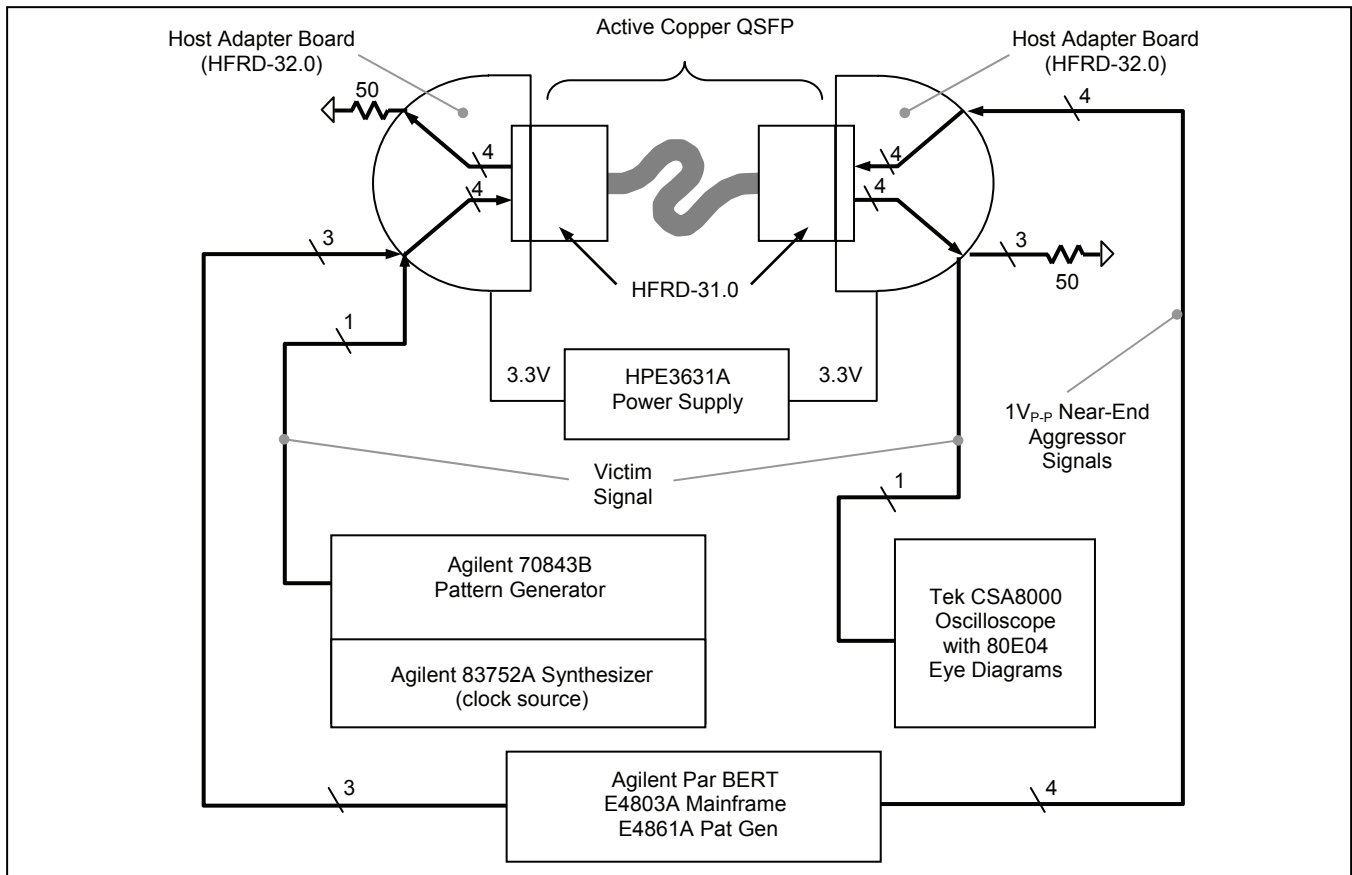


Figure 1. Typical test apparatus fills all channels to evaluate performance in the presence of interfering aggressor signals.

ParBERT is a trademark of the Agilent Technologies Inc

4 Control Interface

Access to QSFP functions is provided by the HFRD-32.0 host adapter board and its associated graphic user interface (GUI) software. Combined, they allow access through a Microsoft Windows-based personal computer equipped with USB. Figures 2 through 10 are examples of the GUI.

4.1 User Interface

The user interface display is divided into two major regions. The uppermost region pertains exclusively to the host board. See Figures 2 and 3. This region includes advisory messages about the status of the communication link with the module, the current and voltage supplied to the module, and the **Initialize** button. The lower region pertains exclusively to module operation. See Figures 4 through 10. Module functions and features are accessed through the tab boxes. A mouse click on a tab reveals the relevant controls.

Monitor Tab—This page displays measurements, alarm flags, warning flags, and other channels' status flags such as LOS and TX Fault. This information is updated based on the selected **Flag Update Method**. The method can be set to update when the Hardware Interrupt Line is asserted, the Software Interrupt Bit is asserted, or by asynchronously polling at two times per second. The flag history can be enabled or disabled to aid in observations. When set to **ON**, asserted flags are retained and can be erased using the **Clear**. When set to **OFF**, the history is not retained. The state of the flags is cleared automatically with each new update.

Interrupt Masks Tab—This page allows the user to prevent (i.e., mask) individual events from generating interrupts. Each event can be masked by clicking the associated radio button beside the event description. Each radio button is an alternate-action function; each click alternates from a masked to an unmasked condition. For convenience, **Set All** and **Clear All** buttons set or clear the entire group. Clicking **Set All** masks the entire group. **Clear All** clears and enables all of the events within the group.

Controls Tab—This page presents the superset of module functions that are defined in the QSFP specification. This does not mean that all modules must implement all functions. Depending on the vendor's implementation, control over TX and RX outputs, squelch, and rate selection are made using this page. The availability of these functions is, finally, determined by a list provided by the module. See **Options Available Tab** to view this list.

Identification Tab—A multitude of identification fields are designated for QSFP modules. This page presents them, as well as the check-sum values stipulated by the QSFP specification.

Read/Write Byte Tab—This page allows the user to access specific locations within the module's memory. QSFP has designated four different Upper Pages to its memory map with addresses (i.e., byte numbers) ranging from 128 through 255. Single-byte reading and writing is available in the **Single Byte** group. The data can be entered as hexadecimal, binary, or ASCII. As the data is typed into one box, its equivalent appears in the other boxes. The **Multi-Byte Read** group requires a starting address and a byte count, and displays the data sequence in hexadecimal, binary, and ASCII formats. When necessary, use the **Password Entry** group to write into protected regions of the module's memory.

Options Available Tab—This page presents the list of optional features available for the installed module. These features are selected by the vendor and determine which functions are relevant to the specific module. For example, a copper cable transceiver will not support optical functions such as TX Bias and RX Power.

HFRD31 Settings Tab—This page only appears if the HFRD-31.0 module from Maxim is detected. The module must have the ASCII characters "HFRD-31.0" as the first nine characters starting at decimal address 168. These controls determine the power-on settings of HFRD-31.0 such as pre-emphasis settings and output enable. This page is also where one can change calibration constants associated with the temperature and voltage monitors.

5 Getting Started

The software is designed to operate on Microsoft Windows 2000 or Windows XP operating systems. The software can also be used on Windows 98, but unstable software operation can occur if the USB cable is unplugged without first stopping the device from windows. This software was built on the Microsoft.NET platform. If the current version of this platform is not already installed on your computer, an internet connection will be needed to download the components and complete the installation.

HFRD-32.0, the QSFP Host Adapter board, can be used with any QSFP module; however, software testing has been limited to Maxim's HFRD-31.0 Quad-SFP Active Copper Cable Assembly reference design. The software that supports HFRD-32.0 is available on CD or from the Maxim web-site at:

http://www.maxim-ic.com/products/fiber/reference_designs.cfm

Instructions for getting started with the QSFP host board are listed below.

Step:

1. Install the reference design software:
 - a. Maxim web site - Download the software (HFRD_32p0_rev1.zip), "unzip" or extract all files and run Setup.exe.
 - b. CD-ROM - Insert the CD-ROM. If the software does not install automatically, run Setup.exe.
2. Connect HFRD-32.0 to the computer using the provided USB cable. When the cable is inserted, a green LED on the board labeled **USB_PWR** should be illuminated.
3. Apply +3.3V across J2 (+3.3V) and J3 (GND) from an external power supply. This supply must be capable of supplying 1.2A at +3.3V to support QSFP modules. If equipped, set the current limit of the external supply to approximately 150mA above the

current required by the module. Turn on the supply. If using HFRD-31.0 as the module, set the current limit to 600mA. The host board will filter the +3.3V supply and route it to the QSFP module as VCCTX, VCCR_X, and VCC1.

4. Run the HFRD-32.0 software from the Windows operating system:
start
↳All Programs
↳Maxim Integrated Products
↳QSFP Host
5. The application should start and appear similar to the top picture in Figure 2.
6. Click **Initialize** in the upper left portion of the display.
7. The display should appear similar to the middle picture of Figure 2. Verify that the two host supply voltages are between +3.2V and +3.4V. The voltage values will be displayed with red text if the supplies are below +3.0V or above +3.6V. Similarly, the supply current values change to red when above 500mA or below 5mA. If the supply current is above 50mA with no module installed, then turn off the supply, check connections, and return to step 3.
8. Install the QSFP module. The software will detect the module's presence and initiate communication. The display should be similar to the bottom picture of Figure 2. The vendor's part number, if available, will appear in the message box. In this example, **Vendor Part Number: HFRD-31.0** is shown.
9. After establishing communication with the QSFP module, the remainder of the QSFP functions will be enabled and accessible. The display should be similar to Figure 4.
10. You are now ready to examine and explore the various pages of monitoring, identification, and control features.

5.1 HFRD-32.0 QSFP Host Adapter Software: Initialization

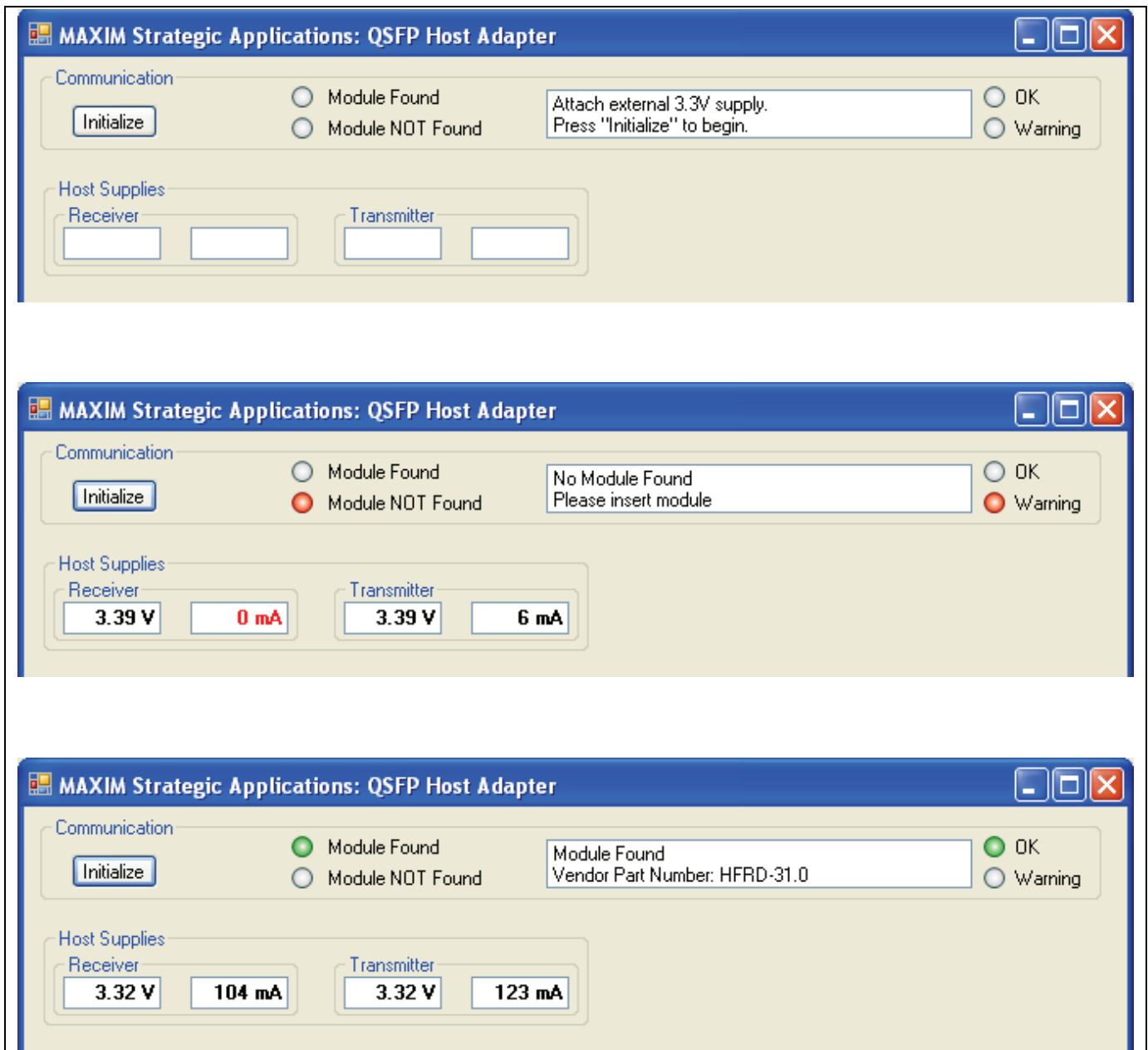


Figure 2. The first three steps to successful operation. Top screen shows the message when the application software is launched; message advises “Press” or click the Initialize button at the upper left. Middle screen shows a typical message after initialization and passing the external power-supply test. Bottom screen shows that a module was detected and its vendor part number retrieved.

5.2 HFRD-32.0 QSFP Host Adapter Software: Supply Monitoring

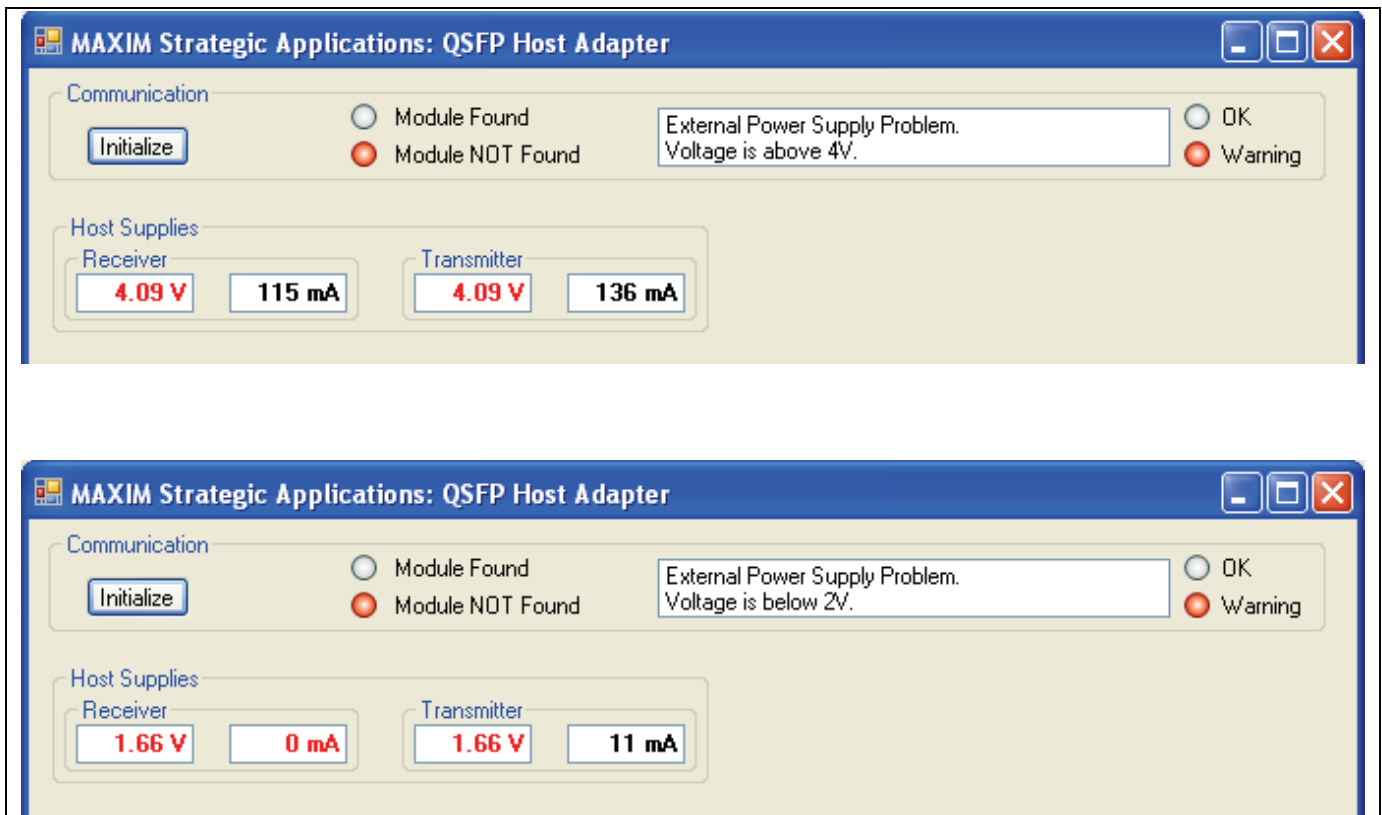


Figure 3. Host supply monitoring advises when the external power supply is out of range. The external supply should be between +3.0V and +3.6V. Supply voltage measurements change color to red when above +3.6V and below +3.0. Similarly, the supply current changes to red text when above 500mA and below 5mA.

5.3 HFRD-32.0 QSFP Host Adapter Software: Monitor Page

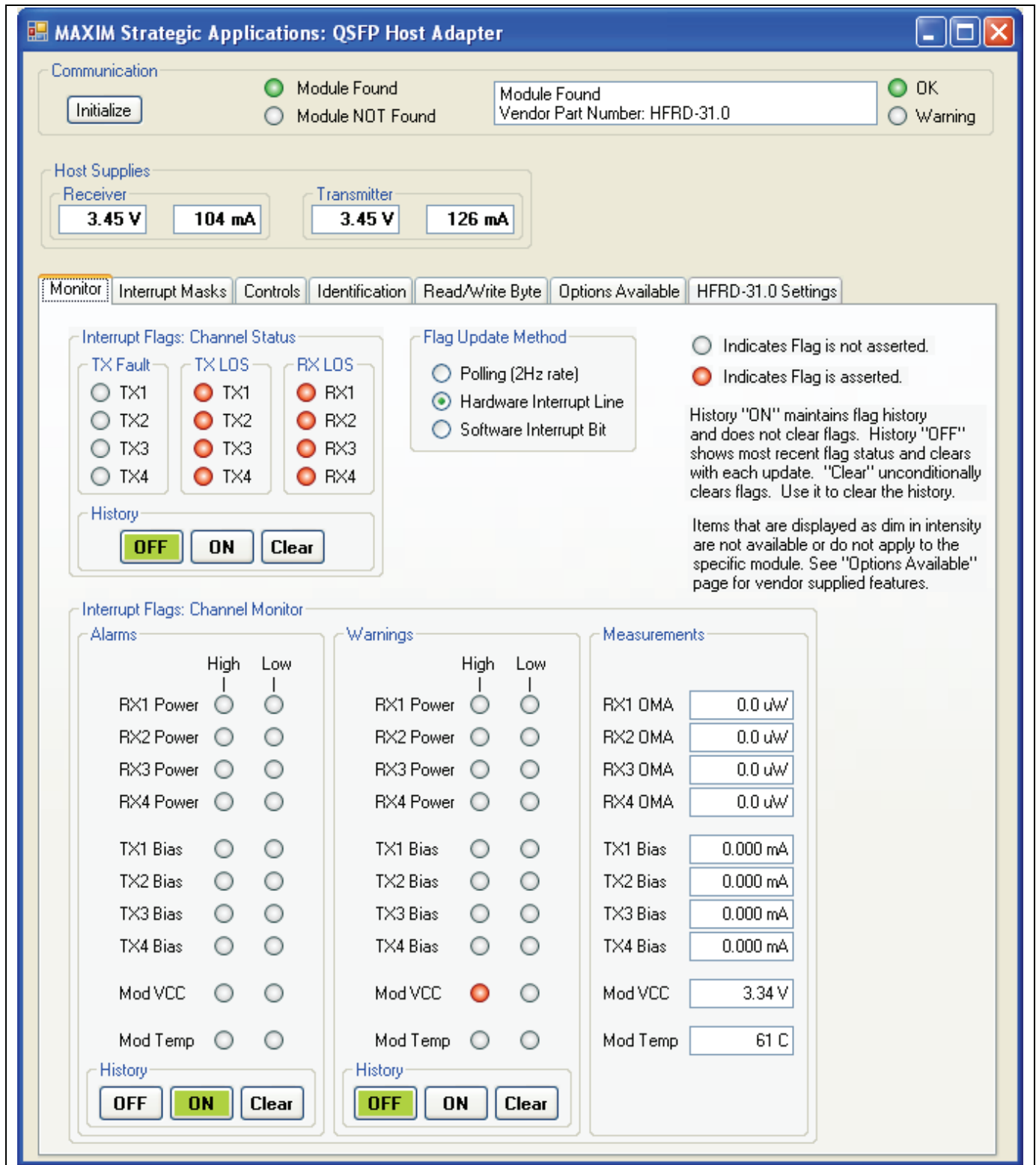


Figure 4. Monitoring includes flag history, measurements and choice of event that forces the update.

5.4 HFRD-32.0 QSFP Host Adapter Software: Interrupt Masks Page

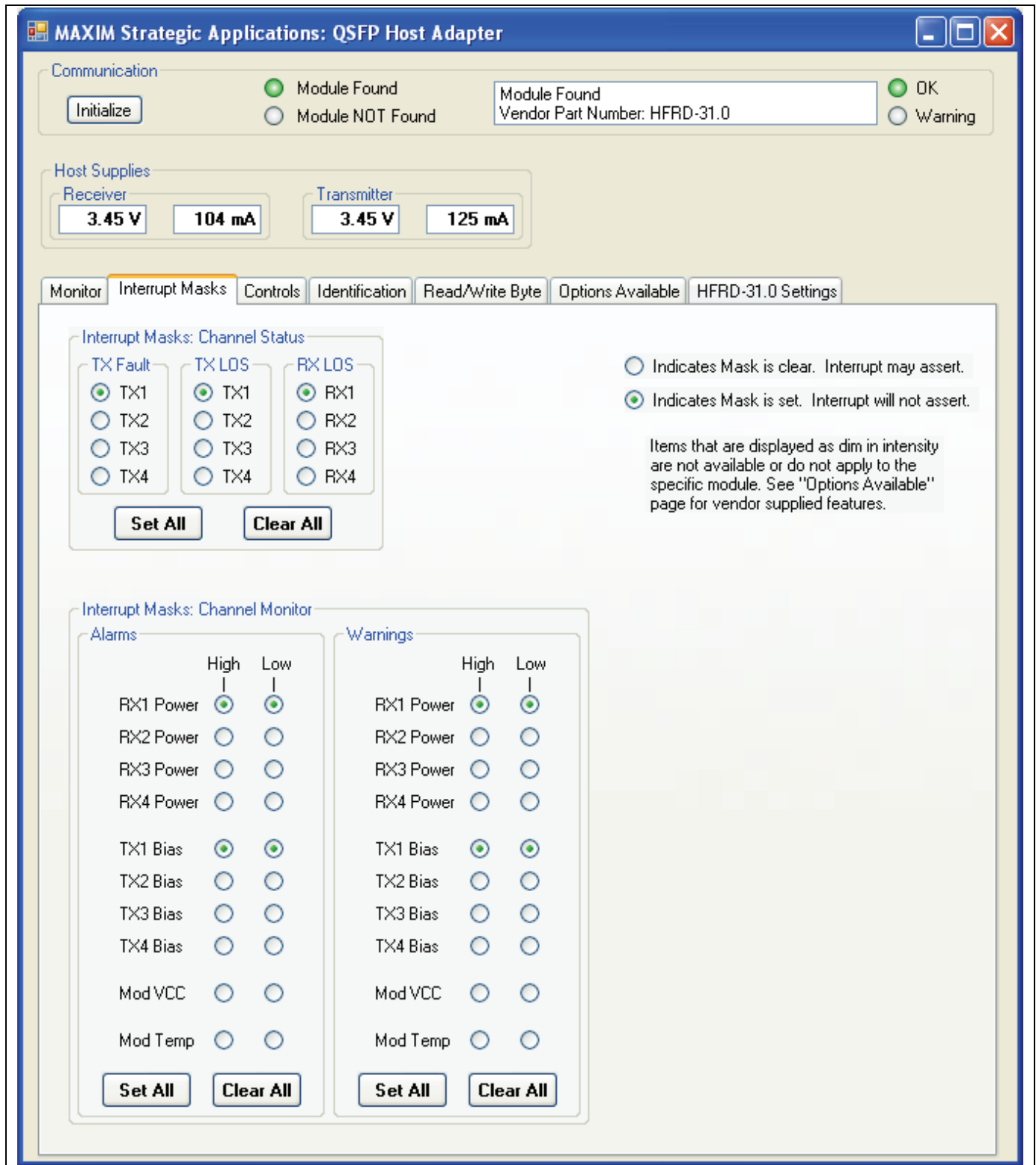


Figure 5. Masks may be set or cleared individually or all at once with the Set All and Clear All buttons.

5.5 HFRD-32.0 QSFP Host Adapter Software: Controls Page

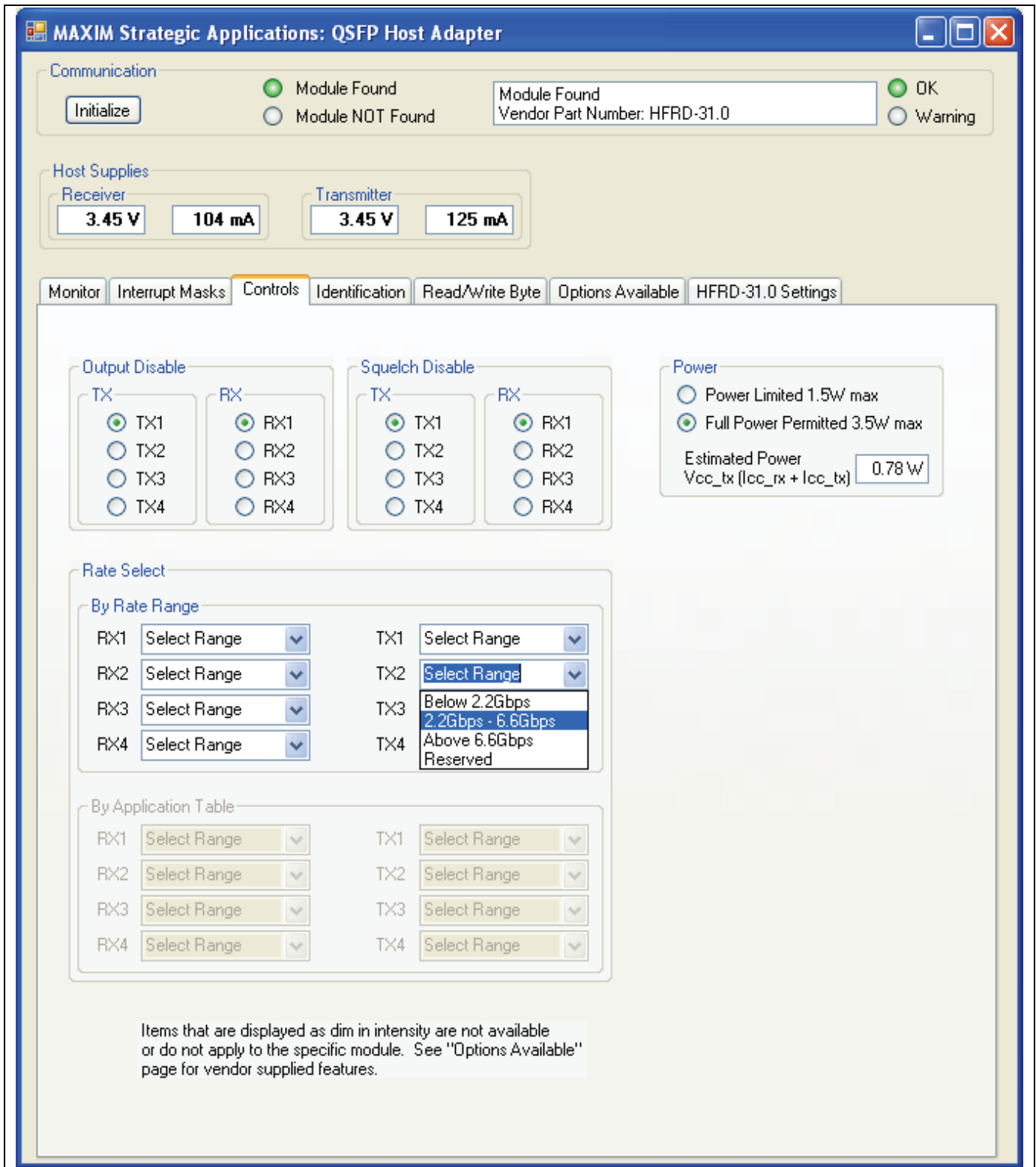


Figure 6. Controls and module power.

5.6 HFRD-32.0 QSFP Host Adapter Software: Identification Page

The screenshot shows the 'MAXIM Strategic Applications: QSFP Host Adapter' software window. The 'Identification' tab is active, displaying the following information:

- Communication:** 'Module Found' status is indicated by a green dot. The 'Vendor Part Number' is 'HFRD-31.0'. Status indicators for 'OK' (green) and 'Warning' (grey) are present.
- Host Supplies:** Receiver: 3.46 V, 106 mA; Transmitter: 3.46 V, 125 mA.
- Identification Section:**
 - General Characteristics:** Module ID: QSFP; Power Class: Power Class 1 Module (1.5 W max); CLEI Code: Not Available; Connector: Copper Pigtail; Data Encoding: 8B10B; Bit Rate: 5.0 Gbps; Extended Rate Select: QSFP Rate Select Version1; Device Technology: Copper; Wavelength Center: Not Available; Wavelength Tol.: Not Available; Max. Temperature: 70 C.
 - Cable Length:** Single-Mode Fiber: Not Available; OM3 Mult-Mode Fiber: Not Available; OM2 Mult-Mode Fiber: Not Available; OM1 Mult-Mode Fiber: Not Available; Copper: 10 m.
 - Supported Standards:**
 - SONET: Not Available
 - Ethernet: 10G Ethernet: Not Available; 1G Ethernet: Not Available
 - Fiber Channel: Link Length: short distance (S); Technology: Electrical inter-enclosure (EL); Medium: Twin Axial Pair (TW); Speed: Click or hover for more information.
 - InfiniBand: Technology: IB 4X Copper; Speed: Click or hover for more information.
 - Vendor:** Name: Maxim HF Apps; OUI: Not Available; Part Number: HFRD-31.0; Revision: A; Serial Number: Serial Number001; Date Code: 14 August 2007; Lot Code: XX; Misc (224-255): Copper Cable Reference Design.
 - Check Sum:** (120-190) Stored: 139, Calculated: 139; (192-222) Stored: 116, Calculated: 116.

A pop-up box titled 'Fibre Channel Speeds' is visible over the 'Speed' field in the Fiber Channel section, listing: 100 MBytes/Sec, 200 MBytes/Sec, and 400 MBytes/Sec.

Figure 7. The numerous QSFP identification fields are shown. When modules report multiple arguments for a given trait, pop-up boxes display a complete list of characteristics.

5.7 HFRD-32.0 QSFP Host Adapter Software: Bit and Byte Level Read/Write

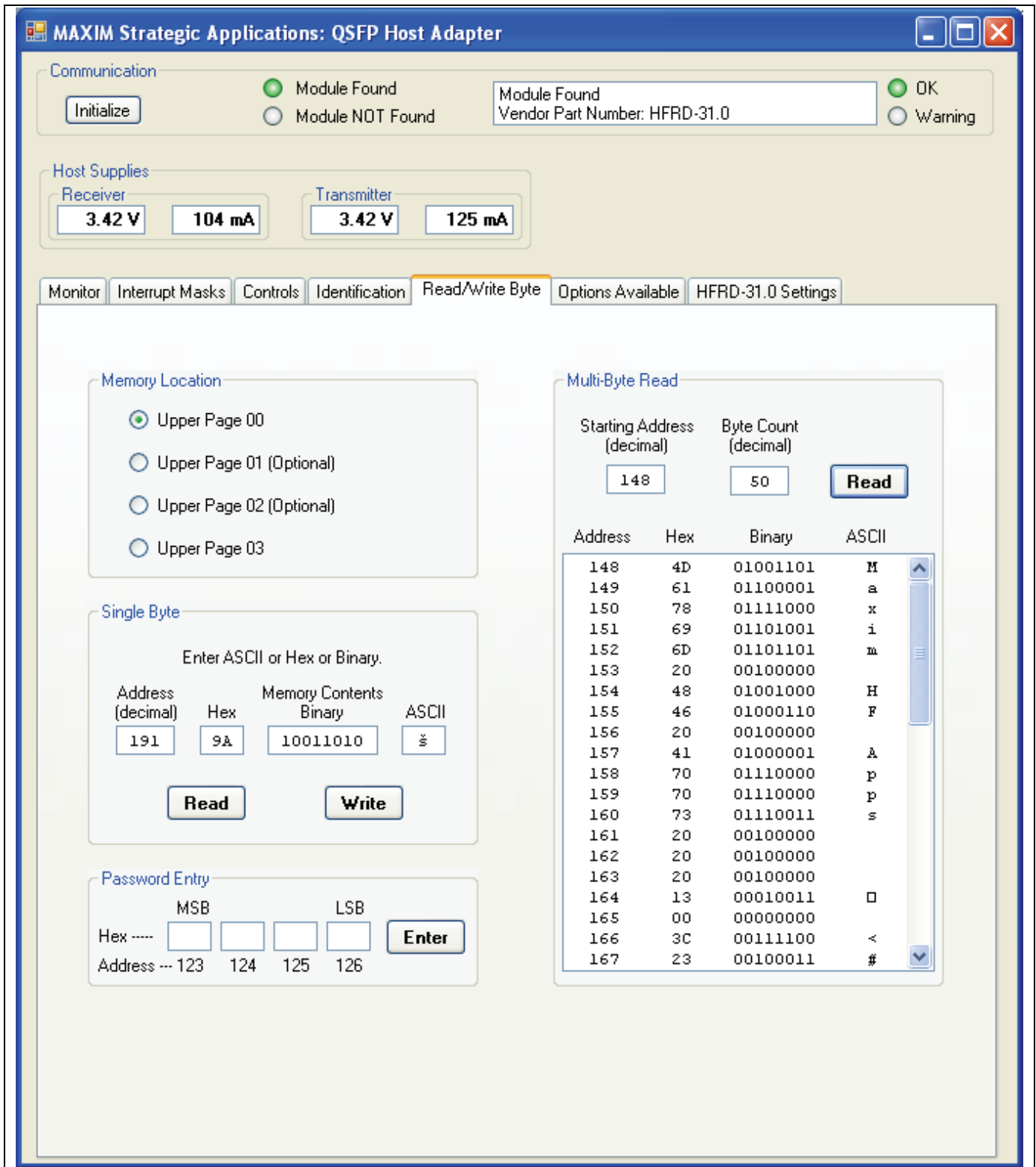


Figure 8. The Read/Write page gives bit and byte-level access to all QSFP memory locations and contents.

5.8 HFRD-32.0 QSFP Host Adapter Software: Options Available Page

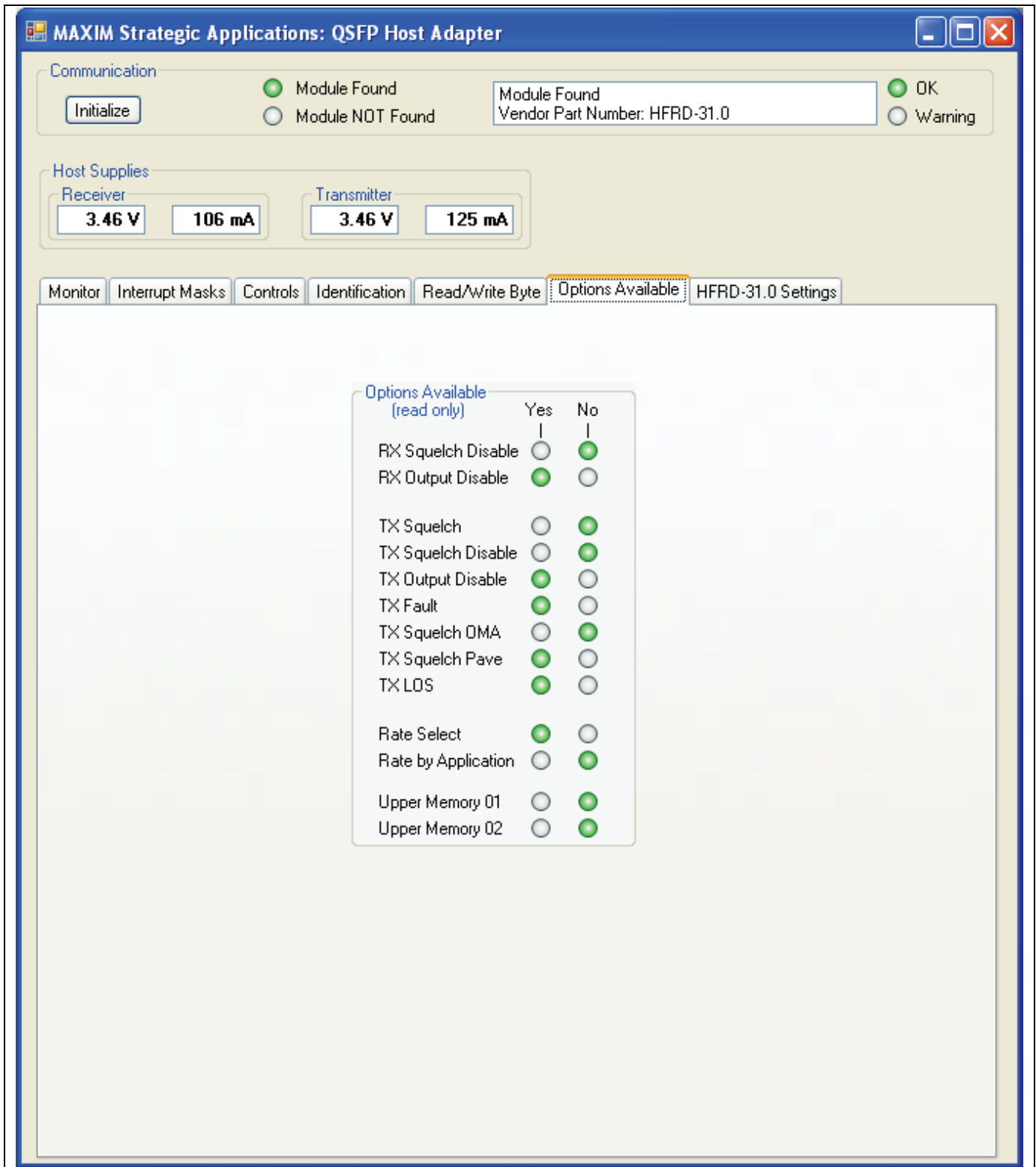


Figure 9. Optional QSFP features are reported by the module and displayed.

5.9 HFRD-32.0 QSFP Host Adapter Software: HFRD-31.0 Specific Controls

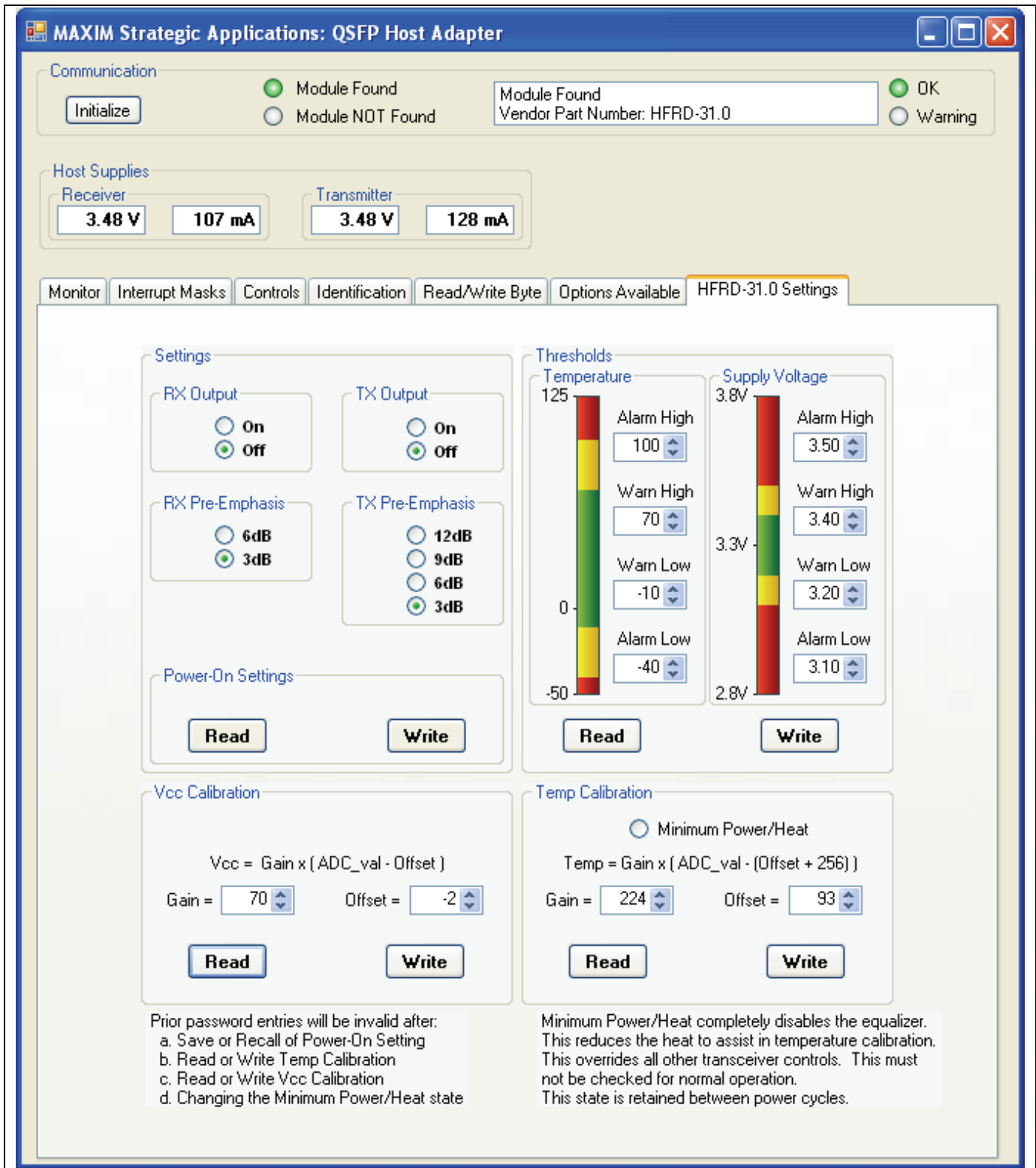


Figure 10. Vendor-specific controls for HFRD-31.0. This menu is present only when the host adapter detects HFRD-31.0.

6 Evaluation

The differential return loss (SDD11) for the board is shown in Figures 11 and 12. Figure 11 shows the SDD11 for all ports, TX and RX, with a 100Ω differential termination in place of the QSFP connector. The QSFP specification does not include a return-loss limit. For this example, the limit from the SFP+ specification is plotted for reference. Compared to this limit, the board offers significant margin, but it does not include the QSFP connector and module. The return-loss requirements will vary depending on the application for a given module. This renders a single return-loss limit

meaningless. For example, a module made for operation at 2.125Gbps should not have to support a return loss of 10dB at 5GHz. The data shown in Figure 12 indicates that HFRD32.0 is adequate for operation at 10Gbps. SDD11 in Figure 12 was acquired with a dummy-load board intended for a maximum rate of 5Gbps. The active devices were removed from the module and 100Ω resistors soldered across the differential lines in the module. Given more care in the layout, it is possible that some improvements could be made. Nonetheless, the current design offers a realistic environment created from practical materials.

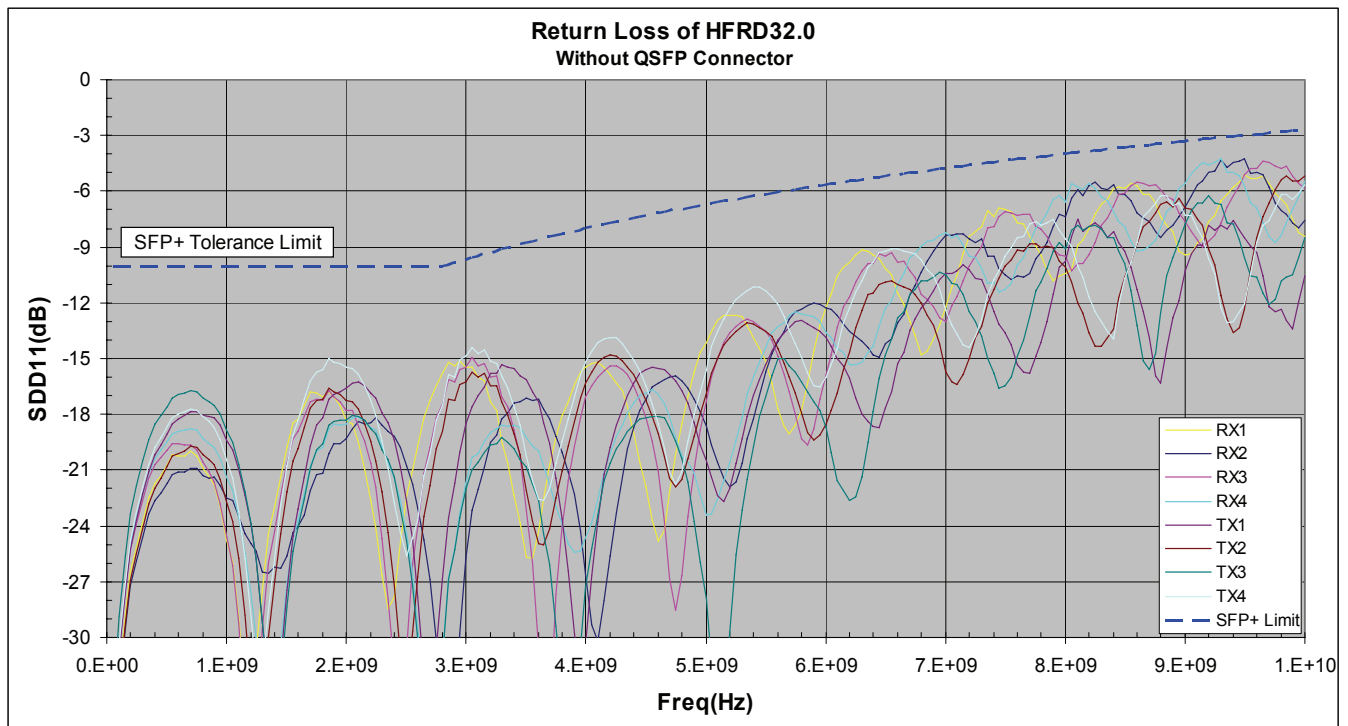


Figure 11. Return loss of HFRD-32.0 without the QSFP connector. The transmission lines were differentially terminated with 100Ω resistors at the QSFP connector landing pads. The SFP+ tolerance limit is included for reference. The QSFP specification does not include a return-loss limit.

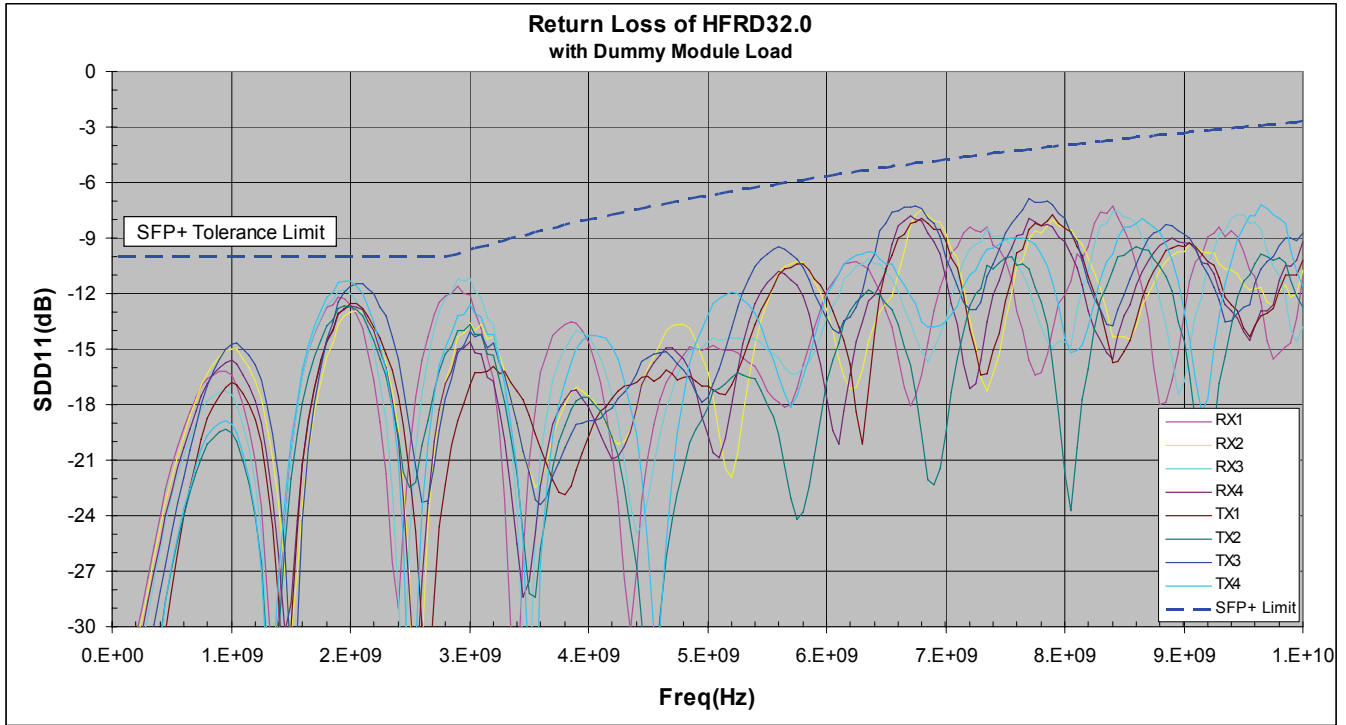


Figure 12. Return loss of HFRD-32.0 including the QSFP connector and a dummy-load module. All active components were removed from the module and the transmission lines were differentially terminated with 100Ω resistors on the module board. The SFP+ tolerance limit is included for reference. The QSFP specification does not include a return-loss limit.

7 Supporting Documentation

7.1 HFRD-32.0 Schematic, Sheet 1 of 2

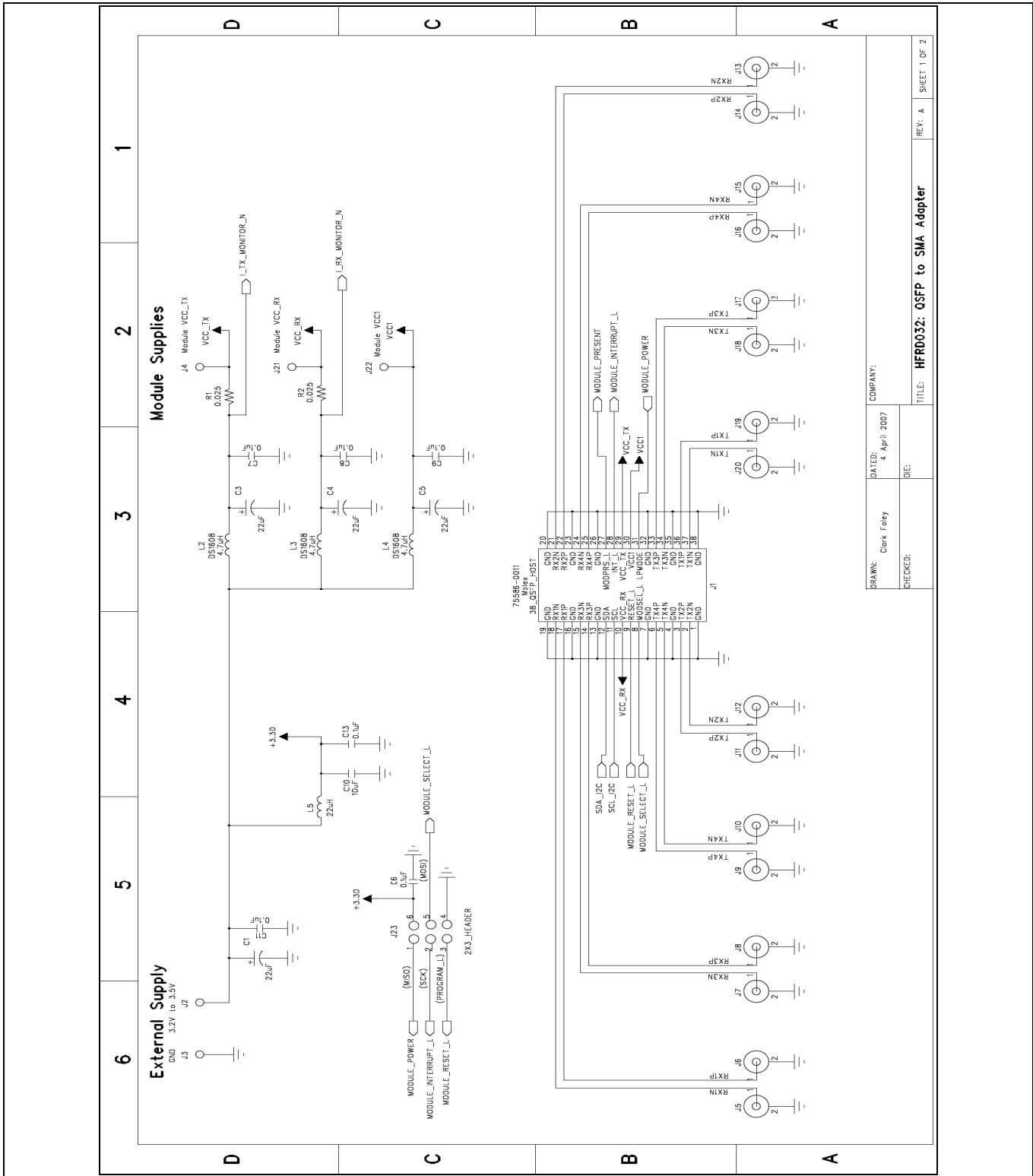


Figure 13. Schematic for HFRD-32.0 showing high-speed data path and supply filters.

7.2 HFRD-32.0 Schematic, Sheet 2 of 2

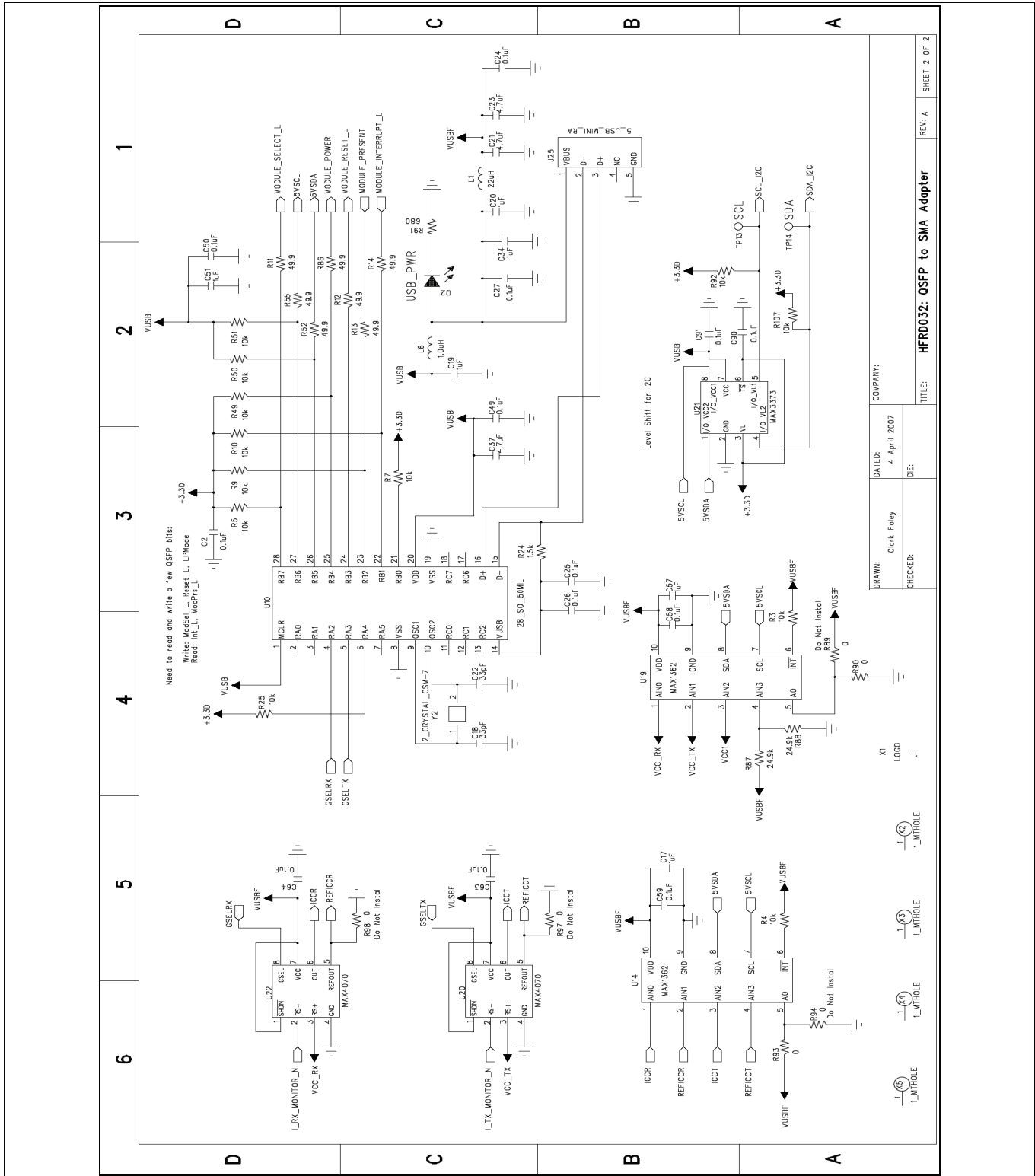


Figure 14. Schematic for HFRD-32.0 showing USB, supply monitors, and micro controller.

7.3 Artwork, HFRD-32.0, Layers 1 and 2

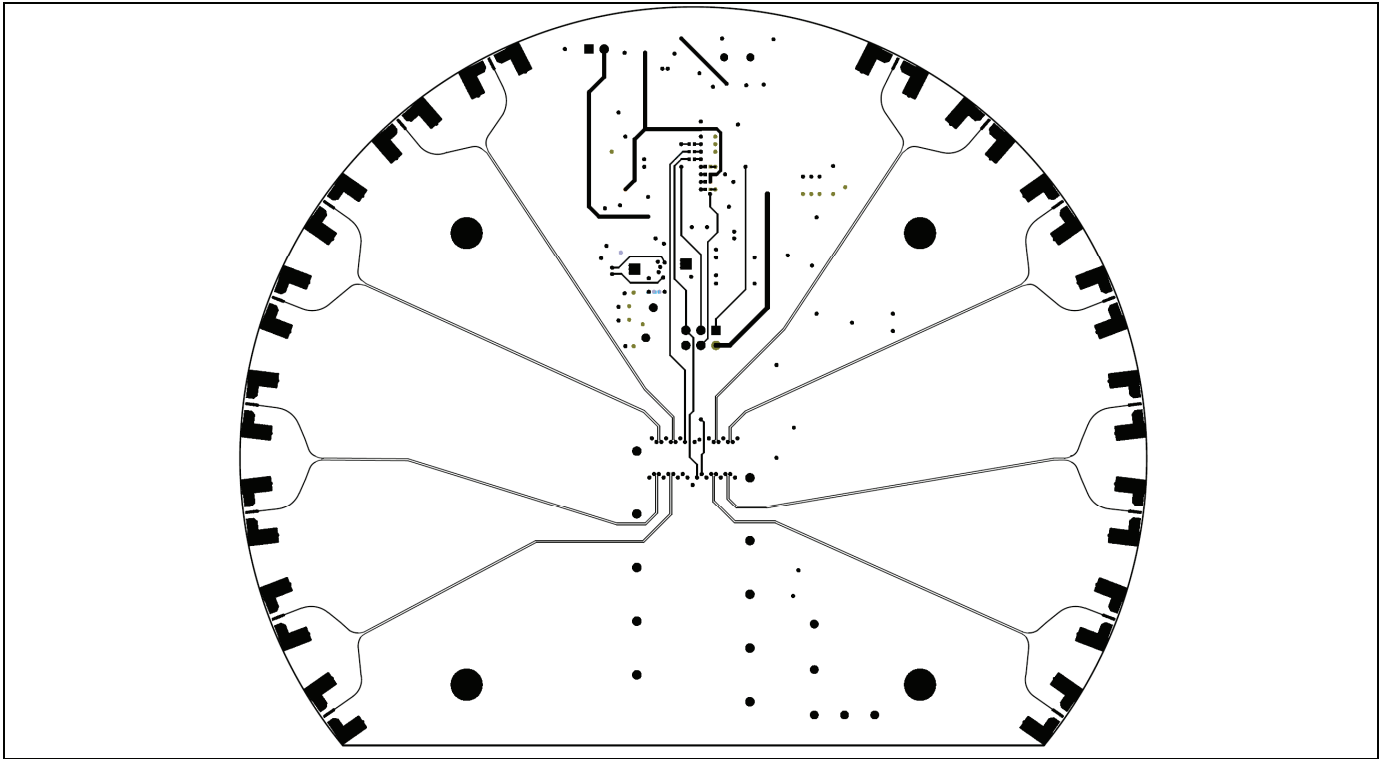


Figure 15. Layer 1 (top), high-speed transmission lines.

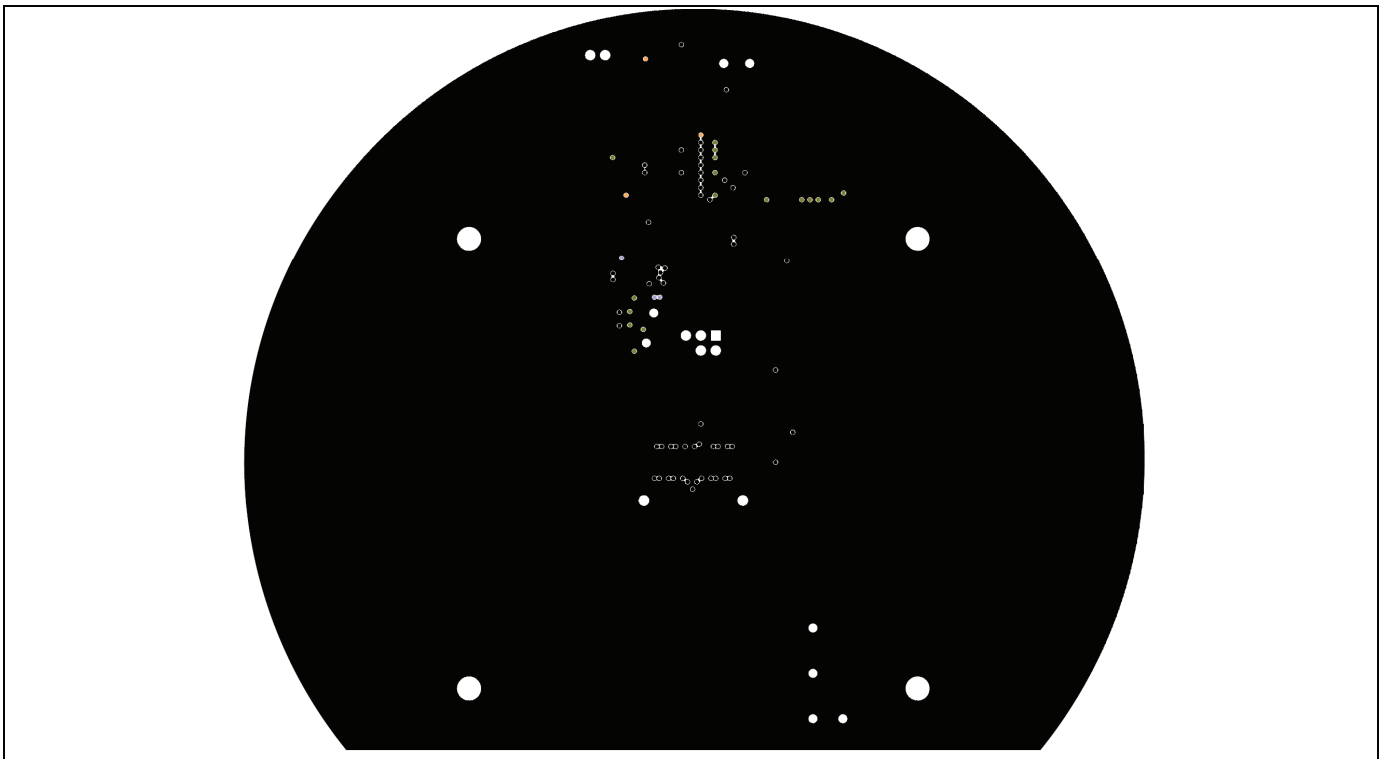


Figure 16. Layer 2, ground and reference plane for layer 1.

7.4 Artwork, HFRD-32.0, Layers 3 and 4

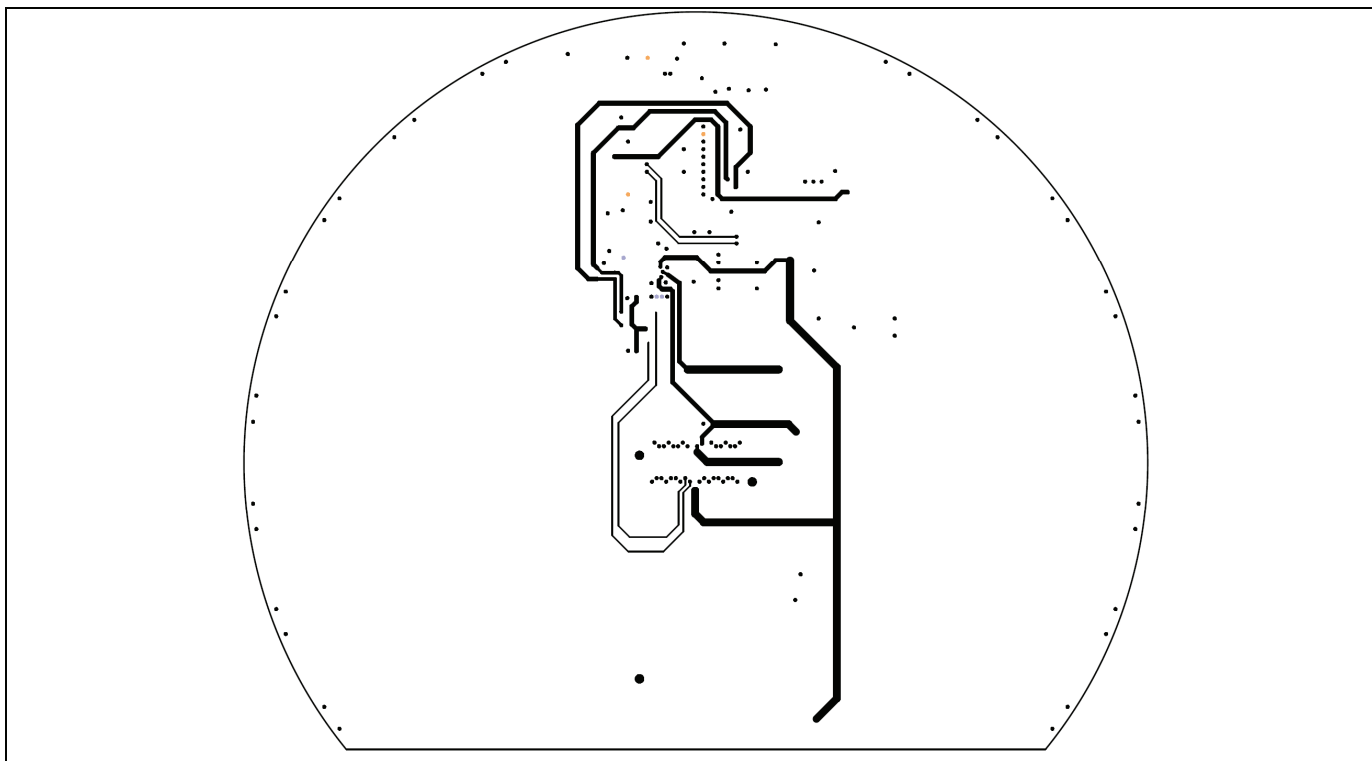


Figure 17. Layer 3, supply routing

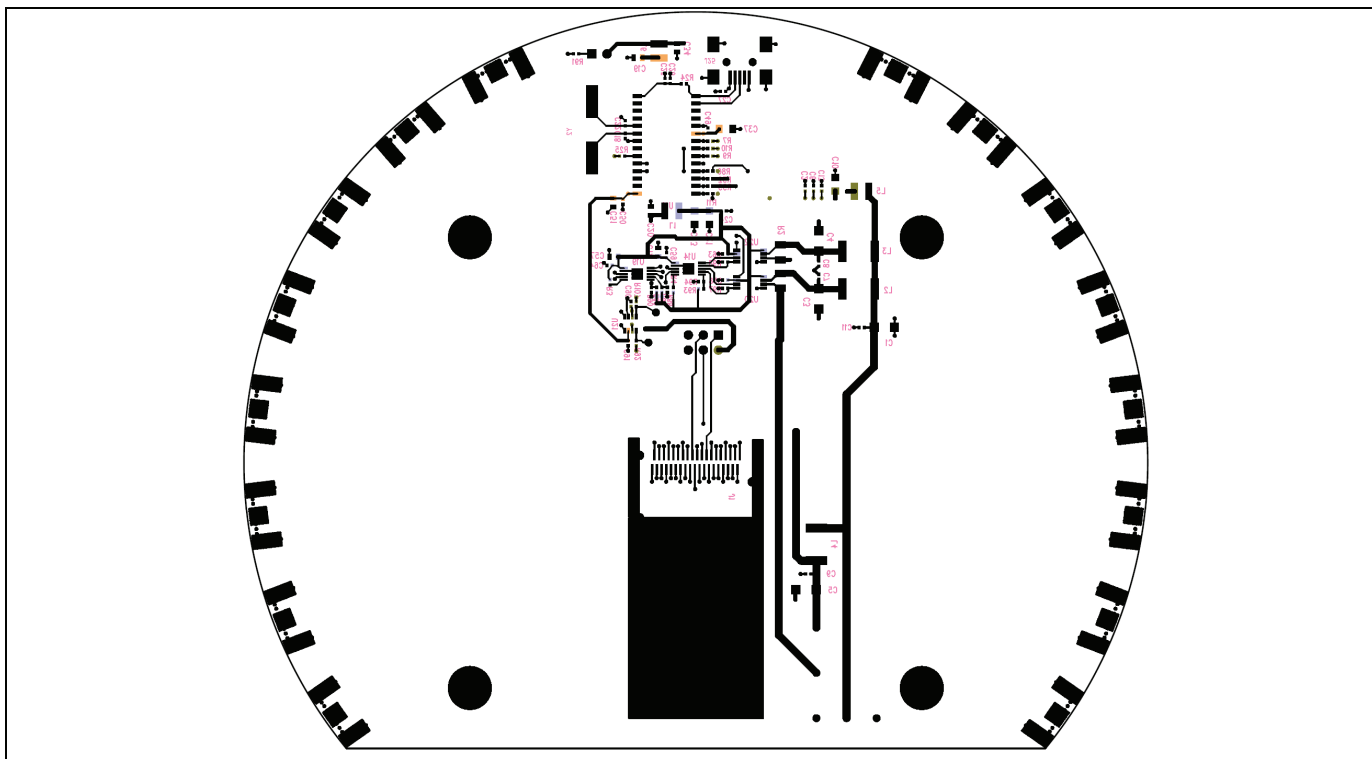


Figure 18. Layer 4, QSFP connector and landing area.

7.5 Component Placement, Front Side HFRD32.0

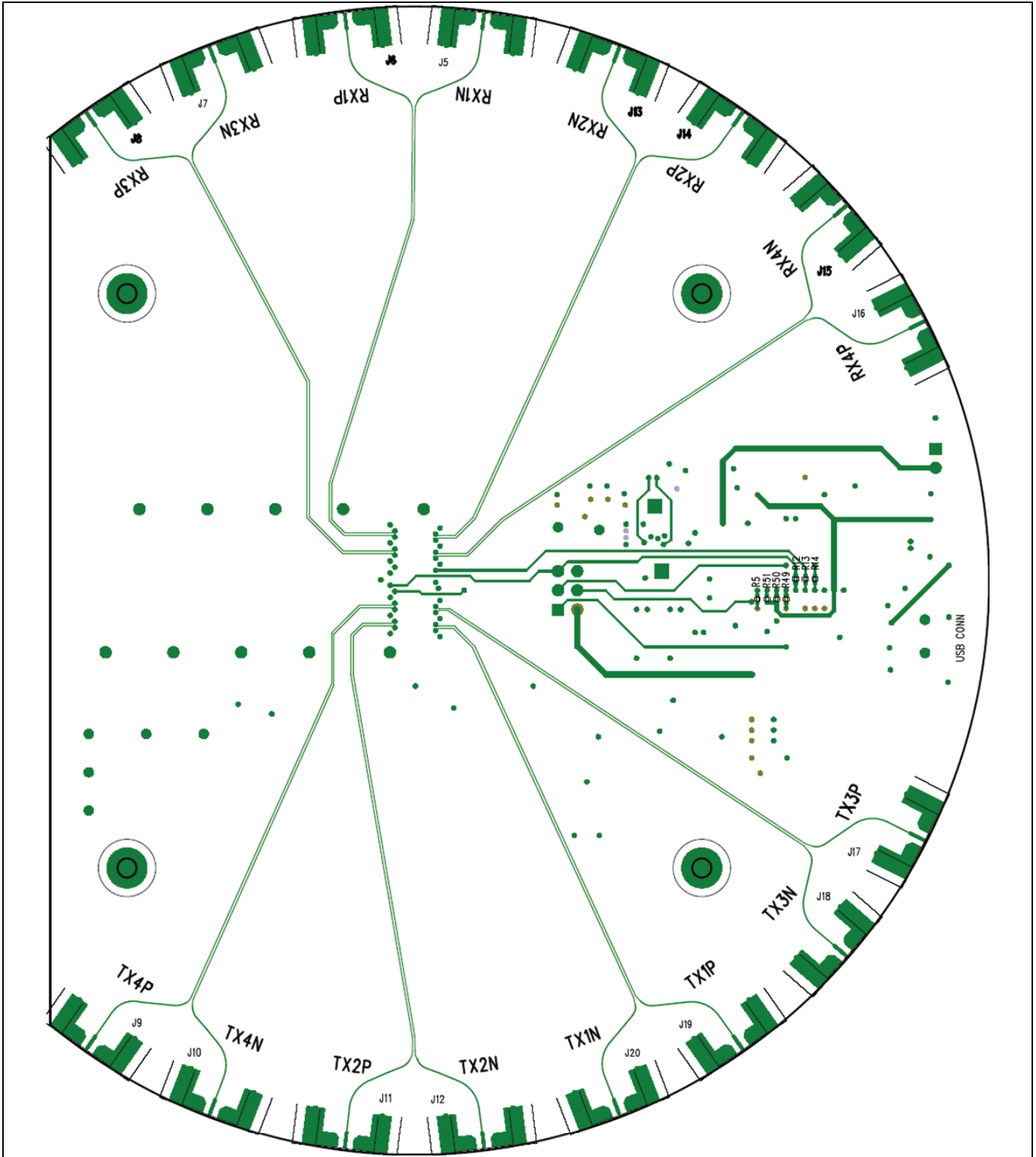


Figure 19. Top (front) layer, transmission lines for high-speed data.

7.6 Component Placement, Back Side HFRD32.0

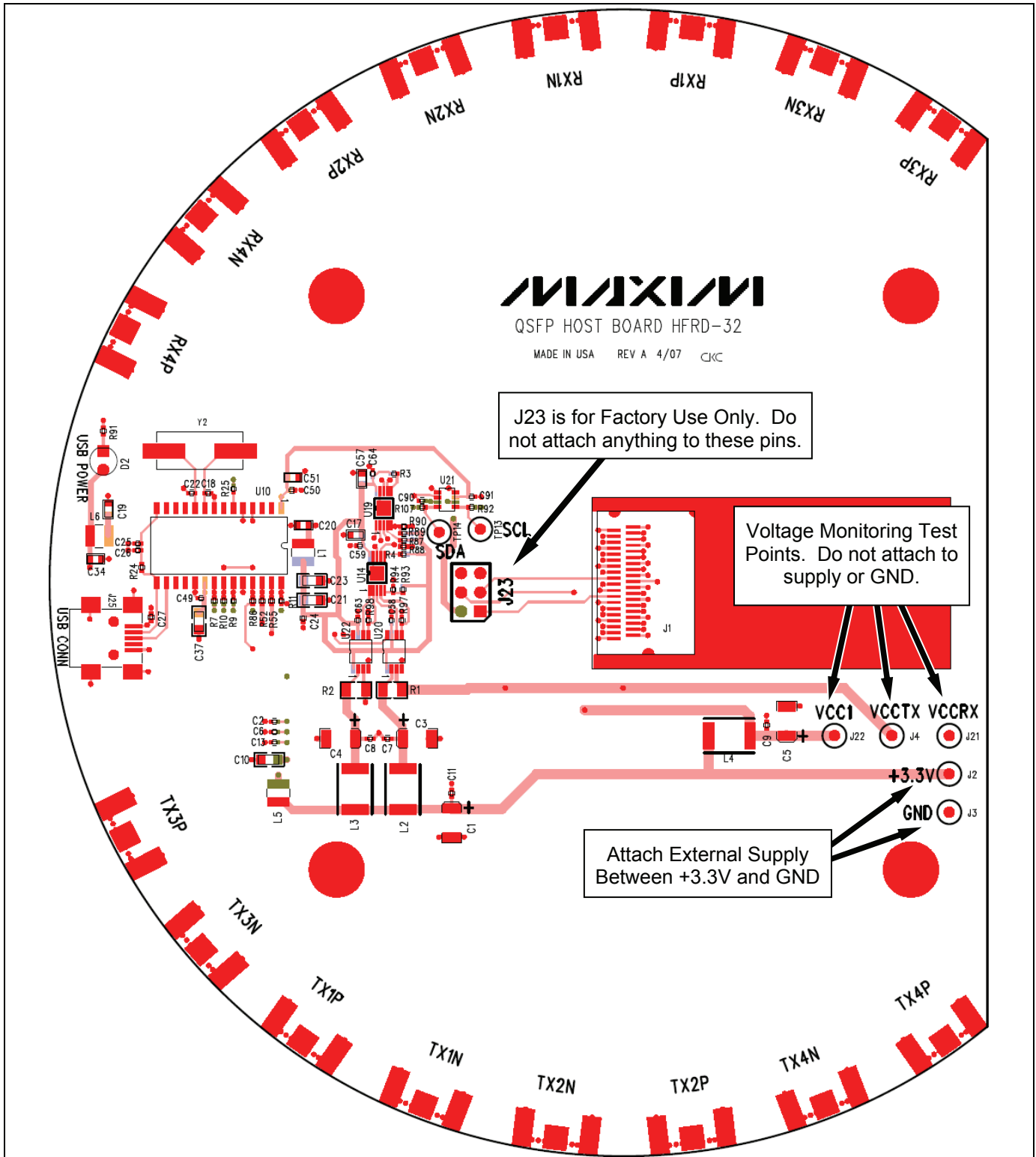


Figure 20. Bottom layer, as viewed from the bottom.

7.7 Mechanical Dimensions, HFRD-32.0

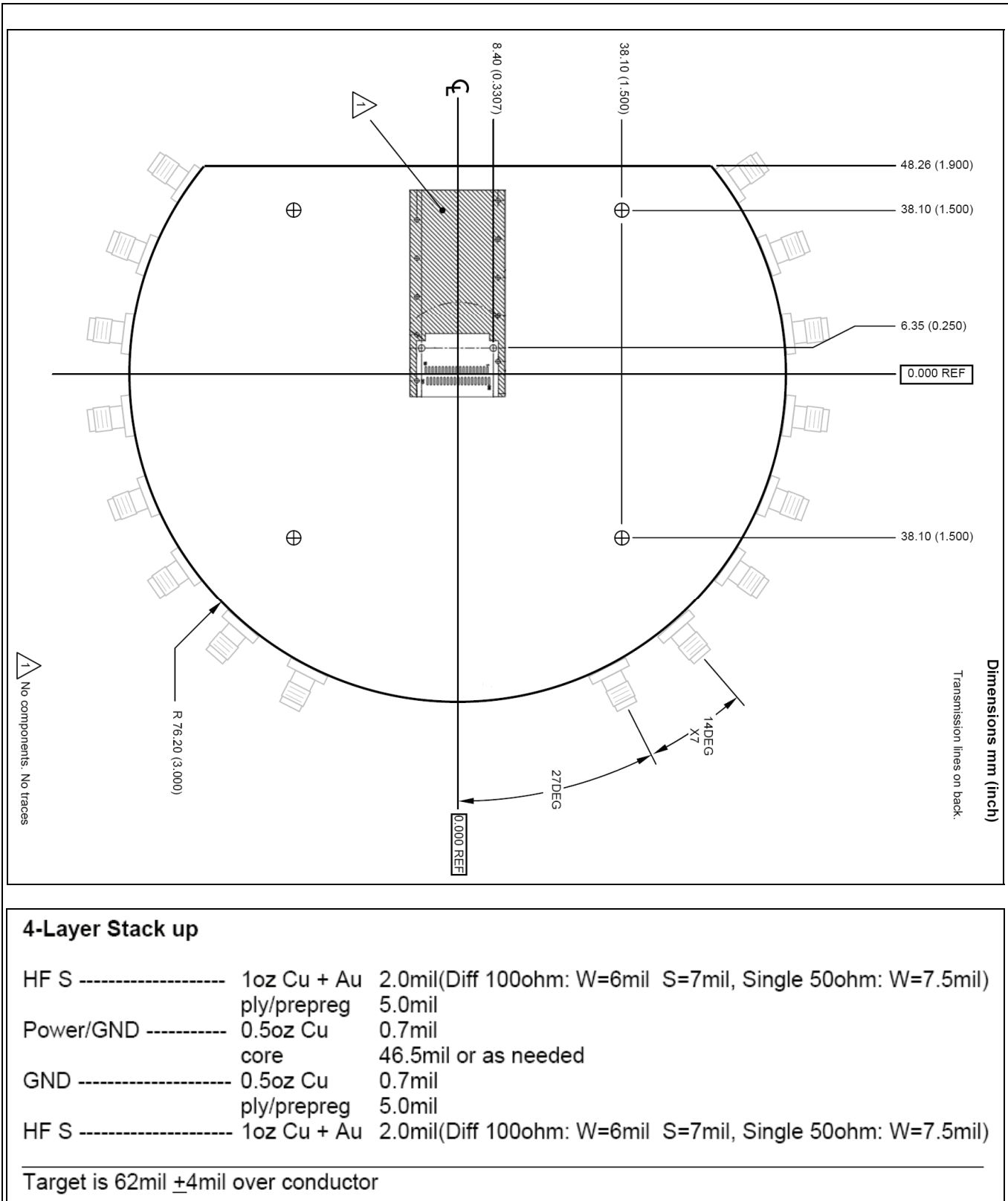


Figure 21. Dimensioned drawing and FR-4 board stackup (loss tangent = 0.02).

7.8 Bill of Materials

Qty	BOM Option	Reference	Value	Tolerance	Description
1		L6	1.0 μ H		Taiyo-Yuden 1.0uH, CBC3225T1R0M
2		L1 L5	22 μ H		Taiyo-Yuden 22uH CBC3225T220MR or CBC3225T220KR
5		J2-4 J21-22			TESTPOINT DIGI-KEY® 5000K-ND
1		U10			Microchip PIC16C745-I/SO
1		J23			
1		Y2			CRYSTAL, ECS INC. XC679CT
1		J1			38-pin iPass SMT Connector, female. Molex number 75586-0011
1		J25			USB CONNECTOR, TYCO 440247-1
19		C2 C6-9 C11 C13 C24-27 C49-50 C58-59 C63-64 C90-91	0.1 μ F	10%	CERAMIC CAPACITOR (0402)
2		C18 C22	33pF	10%	CERAMIC CAPACITOR (0402)
6		C17 C19-20 C34 C51 C57	1 μ F	10%	CERAMIC CAPACITOR (0603)
1		C10	10 μ F	10%	CERAMIC CAPACITOR (0805)
3		C21 C23 C37	4.7 μ F	10%	CERAMIC CAPACITOR (0805)
4		C1 C3-5	22 μ F	10%	TANTALUM CAPACITOR 1206
3		L2-4	4.7 μ H		Coilcraft Power Inductor DS1608-472MLB
1		D2			GREEN LED
2		U14 U19			MAX1362EUB
1		U21			MAX3373EEKA-T
2		U20 U22			MAX4070AUA
4	Do Not Install	R89 R94 R97 R98	0		RESISTOR (0402)
2		R93 R90	0		RESISTOR (0402)
1		R24	1.5k	1%	RESISTOR (0402)
12		R3-5 R7 R9-10 R25 R49-51 R92 R107	10k	1%	RESISTOR (0402)
2		R87-88	24.9k	1%	RESISTOR (0402)
7		R11-14 R52 R55 R86	49.9	1%	RESISTOR (0402)
1		R91	680	1%	RESISTOR (0402)
2		R1-2	0.025	1%	RESISTOR (1206) 0.125W
16		J5-20			SMA SIDE MOUNT TAB CONTACT JOHNSON 142-0701-851
2		TP13-14			TESTPOINT DIGI-KEY 5000K-ND

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